

AGRICULTURE, FOOD AND NUTRITION SCIENCES DIVISION

THE FIRST FIVE YEARS



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**Agriculture, Food and Nutrition Sciences Division:
The First Five Years**

(A Division of the International Development Research Centre)

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The purpose of this booklet is to provide basic information about the Agriculture, Food and Nutrition Sciences Division of the International Development Research Centre (IDRC). It describes the objectives, priorities, and operation of the Division, and gives some examples of research projects undertaken in developing regions under its auspices.

What is IDRC?

The International Development Research Centre is a public corporation established in 1970 to stimulate and fund research in developing countries, adapting science and technology to meet the challenges of development. Special emphasis is given to the problems of rural areas.

IDRC believes that research constitutes a major catalyst to development and change in science and technology. In general, developing countries have had little involvement in research and have received a correspondingly small share of the benefits associated with it, not only in terms of goods and processes, but also of trained manpower. IDRC hopes to help correct this imbalance.

One of the main goals of the Centre is to help developing regions to build up their own research capabilities and the innovative skills needed to solve their problems. Therefore, developing country researchers are responsible for identifying, designing, and carrying out the research itself, with funds provided by the Centre. The Centre also emphasizes the coordination of research between developing countries and regions, and encourages cooperation between the developing country researchers and institutions in Canada and in other developed nations.

A research project proposal from a developing country is considered in the light of the following criteria:

- Does the proposal fit into a priority expressed by a government or research institute in a developing country?
- Are the research findings likely to have useful application over a region and in countries beyond the one in which the research takes place?
- Will the research help close gaps in living standards inside those countries, and lessen the imbalance in development between rural and urban areas?
- Will it make the fullest possible use of local resources and research workers from the region?
- Will it result in better trained and more experienced researchers?

The Agriculture, Food and Nutrition Sciences Division is one of five program divisions; the others are Health Sciences; Social Sciences and Human Resources; Information Sciences; and Publications.



Foreword

The Agriculture, Food and Nutrition Sciences (AFNS) Division of IDRC has had an effective life of a little more than five years. The Director was appointed in late 1970 and the first four Associate Directors during 1971.

Altogether, up to 31 March 1977, the Division has supported 235 projects in 50 countries. Of the total appropriation on projects of about \$47 million between 1971 and 31 March 1977, 34% was on projects in Asia, 26% in Africa and the Near East, and 30% in Latin America and the Caribbean. About 9% was devoted to general global and Canadian projects.

In addition, the Division has sponsored 86 workshops and symposia in various countries.

Over the past five years, roughly 50% of the budget was in support of crops and cropping systems research, 21% on animal sciences, 11% each on fisheries and forestry, and 7% on what are best described as postproduction systems, including food preservation, processing, storage, distribution, and utilization in the home.

The staff of the Division embodies roughly 200 man-years of active experience in international development, much of it working with farmers, fishermen, and small rural industries.

The purpose of the Division, consistent with IDRC's policy, has been to support applied research for the benefit of poor rural people. Highest priority was therefore assigned to the food and tree crops of the arid and semi-arid tropics; to root crops, that provide basic subsistence for more than 300 million people; to artisanal fisheries and small-scale fish culture; to by-products and agricultural wastes as animal feed on small farms; and to combined farming systems that will most benefit the poorer rural communities.

It must be emphasized that IDRC exists to encourage and support applied research, not itself to undertake research. Expatriate scientists have been provided only where specifically requested. In virtually all such cases, these scientists have been young and have worked as members of a research team directed by a leader from the recipient country. The expatriates do not act as project managers or leaders. Consequently, what is reported in this publication results almost entirely from the dedicated efforts of many Asian, African, Caribbean, Latin American, and Near Eastern scientists. Theirs is the achievement: the role of the AFNS and other divisions of IDRC has been to encourage and support them, where required, with relevant information, technical and administrative advice, facilities for training, and, perhaps most important, with the means to communicate regularly with other scientists and scientific institutions.

Wherever and whenever possible, cooperative linkages have been forged between research institutions in developing countries and relevant international or regional research centres. In special cases, supporting studies of important fundamental problems have been contracted with Canadian universities.

Perhaps the most important function of the Division has been to enable scientists of related disciplines or interests in developing countries to meet regularly, first to define cooperative research programs, and subsequently and regularly to exchange their results and experience. As a result, several continuing and mutually supporting cooperative networks have come into being: in savanna forestry in semi-arid Africa; in aquaculture in Asia; and in postproduction systems research in Asia. Other networks under development include root crops research in Latin America; food technology in the Near East; and agroforestry on a worldwide basis.

IDRC can perhaps best be regarded as a catalytic agent and a provider of supporting services, services that seek to help young scientists in developing countries to become more efficient applied scientists and research managers.

J. H. Hulse

Director

Agriculture, Food and Nutrition Sciences

Introduction

Very early in the history of IDRC the Centre's Board of Governors agreed that high priority would be given to the food and subsistence needs of people in the rural areas of the developing world, particularly those living in the semi-arid tropics. This decision inevitably placed strong emphasis on the work of the Agriculture, Food and Nutrition Sciences (AFNS) Division — an emphasis that is reflected in the proportion of Centre funds disbursed for projects through the Division (43.4% during the first five years).

At the outset it was agreed that a desk in Ottawa was not the ideal place from which to develop an effective program of agricultural research intended to benefit the least fortunate people of the Third World. Thus the Division's associate directors are based away from Ottawa in locations where they can work most effectively in close association with their own disciplines. Some are at universities in Canada, others as far afield as Colombia, Kenya, and Senegal. All program officers are also based in the field, at the Centre's regional offices in Bogota, Cairo, Dakar, Nairobi, and Singapore. In this way the staff are able to keep in direct contact with the needs of the developing countries in addition to maintaining an active professional involvement in their own field of specialization.

The Division's program of work and budget are organized according to conventional disciplines into five programs — Crop Sciences and Cropping Systems; Animal Sciences; Fisheries; Forestry; and Food Science and Nutrition (which might better be termed postproduction systems research) — with an associate director responsible for each.

IDRC is a member of the Consultative Group on International Agricultural Research (CGIAR), which supports a network of international agricultural research centres (IARCs) each of which is dedicated to increasing food production in developing countries. The work of these IARCs is now a central factor in the Division's activities. The Division contributes directly to the network through support for a number of individual projects being undertaken by the various centres, and less directly but more intensively through support for university, national, and regional research and training programs that are linked in one way or another to the work of the IARCs.

In addition, the Division assisted the Ford Foundation in creating the Institute for Crops Research in the Semi-Arid Tropics (ICRISAT), the first of a series of new IARCs sponsored by CGIAR. Subsequently IDRC was appointed by CGIAR as executing agency for the creation of the International Livestock Centre for Africa (ILCA), which now has its headquarters in Addis Ababa, Ethiopia, and for the establishment of the newest member of the family, the International Centre for Agricultural

Research in Dry Areas (ICARDA), which will carry out research in crops and farming systems of importance to the Mediterranean, the Near East, and North Africa.

Although support for research projects proposed, defined, and executed by scientists in developing countries is the most important component of the Division's program, a great deal of effort also goes into establishing and maintaining linkages among projects having a common or related goal. Many institutions in developing countries lack the human or financial resources to undertake all the research needed by their countries in any given area of agriculture, forestry, fisheries, and related sciences. At the same time, many countries, particularly those in the same agroclimatic zone, experience similar conditions, opportunities, and needs. By bringing together, for example, all the forestry research directors from the semi-arid countries of Africa, it was possible to map out a comprehensive and integrated program of research that is more diverse and more demanding of resources than any single country could provide, yet to which each country can contribute a significant component. In several instances the Division provides a technical advisor or network coordinator who helps to hold all the research pieces together and acts as a focal point for information exchange and technical advice and support.

Where necessary the Division supports research in developed country institutions in support of projects under way in developing countries. Every applied research project brings to light from time to time problems that require a more fundamental study — such as studies of the physiological mechanism of tolerance to drought stress in sorghum, or the production of disease-free cassava plants by tissue culture. Where the facilities for such research do not exist either in the country concerned or the appropriate IARC, the Division lets contracts to research institutions in Canada or other developed countries. In almost all such instances the research involves graduate or postdoctoral scientists from developing countries, which thus helps build up a greater capacity for agricultural research in the Third World.

The Division also provides a variety of supporting services and activities aimed at filling gaps in knowledge and rounding out the various research networks and projects into a more comprehensive whole. These activities include state-of-the-art reviews, the sponsoring of international expert working groups to identify specific research needs, bringing together different international scientific bodies to tackle a common problem, and the provision of special consultants to IARCs, regional, and national programs.

The projects supported by the AFNS Division also benefit from the financial, legal, and administrative guidance the Centre is able to provide, and from the services of the other program divisions. Social Sciences and Human Resources makes possible pre- and postproject training programs, Information Sciences provides abstracting and other data retrieval services, and the Publications Division prepares, edits, and publishes project reports and other documents arising from projects and meetings.

Crop Sciences

The poorest people of the developing countries derive perhaps 75% or more of their calories and protein from plant sources. Yet the important cereal grains, food legumes, and root crops that provide the main subsistence for these people have been largely neglected in favour of cash export crops that were assigned the highest priority by former colonial administrations. It is because of this situation that the Crop Sciences program absorbs the lion's share of the division's budget.

The program falls into five main categories: crops of the semi-arid tropics; rice and related cropping systems; triticale; crops and cropping systems for high altitudes and other "marginal" arable lands; and cassava.

Crops of the Semi-Arid Tropics

The term "semi-arid tropics" cannot be precisely defined, but in general it embraces those regions in which evapotranspiration exceeds rainfall for more than half the year. These include most of the countries surrounding the Sahara, much of East Africa, a significant area of Central India, and some of the regions of Southeast Asia and South America. In most of the semi-arid tropics rainfall distribution and frequency are variable and unpredictable, as has been exemplified by the Sahel zone of Africa and much of India during recent years.

The principal crops of these regions are the cereal grains sorghum and the millets — a term that in general means "small grains" and includes a large number of different genera. The total world acreage of sorghum and millets probably exceeds 70 million hectares, which is close to the global acreage under maize. Yet in the developing world the average yield of maize is close to 1.25 tons per hectare, whereas sorghum and millets yield barely 0.5 tons. In the USA, where sorghum is grown as a feed grain, average yields are seven times those attained in India and Africa. Clearly the opportunity exists for increasing yields in Asia and Africa through applied research and improved agronomic practices.

The other important crops of the semi-arid tropics are the food legumes, including groundnuts, chick-peas, pigeon peas, cowpeas, and other beans; and a variety of oilseeds, including safflower, sesame, rape, and mustard. An important characteristic of all these crops is their ability to produce a harvestable crop under drought conditions.

The hub of semi-arid crops research is ICRISAT, which bears the international responsibility for improving sorghum, pennisetum millet, groundnuts, chick-pea, and pigeon pea. The project network supported by the IDRC is linked with the central ICRISAT program, and each of the



Extension worker and small farmer in Senegal discuss the millet crop.

individual projects receives breeding materials and technical support from ICRISAT, and contributes to the ICRISAT germ plasm collection.

The Centre has also established several contract research projects with research institutions in developed countries exploring problems of fundamental importance to the sorghum, millet, or legume improvement programs in the semi-arid tropics. The Canadian universities, Laval and Saskatchewan, are studying the biological factors that influence the ability of sorghum to tolerate continuous or intermittent drought stress; at Saskatoon the scientists are developing methods to extract and purify the plant hormones that are believed to regulate sorghum's responses to drought and other stresses.

At the University of Sussex, the Centre is supporting contract research into parasitic weeds such as striga and orobanche, which cause serious damage to sorghum and legume crops in many countries of Africa and the Near East and Asia. Trials are now underway in these regions, using substances synthesized at Sussex, to try to cause striga and orobanche seeds to germinate before the crops are planted. If this can be achieved, the weeds will germinate and die with no host to which to attach themselves.

An Indian chemist working at the University of Sheffield has identified the "tannins" present in the seed coats of many sorghums that seriously impair the digestibility and nutritional value of sorghums, millets, and possibly several legumes. Through further research it should be possible to determine whether they can best be eliminated by selective breeding or by an inexpensive postharvest process.

Sorghum and millets

One of the largest and most comprehensive projects with which the Division has been associated is the Arid Lands Agricultural Development program (ALAD), which, through research and training, serves some 16 countries, from Pakistan in the east to Morocco in the west, and from Turkey in the north to Ethiopia in the south. The ALAD program, which has now given way to the new international centre, ICARDA, was financed jointly by IDRC and the Ford Foundation, and made progress not only in the breeding and selection of improved sorghums, millets, and legumes, but also in creating a greater awareness of their potential among governments of the region and in training plant scientists.

In Senegal scientists at the National Agronomic Research Centre (CNRA) are seeking high-yielding, fast-growing sorghum varieties that can be planted at the beginning of the 3-month rainy season and will mature before it ends, allowing farmers to plow the alluvial clay soil before it is baked hard by the sun. Some very successful research has been carried out to develop sorghums that mature within 90 days, some of which give yields on test plots of 8 tons per hectare, compared to the national average of 0.5 tons. The project includes a novel training component in which eight young scientists from the region working toward their Master's Degree received their basic formal training at Laval University before returning to the CNRA to carry out the experimental work for their theses under the joint supervision of CNRA scientists and professors from Laval.

In Ethiopia IDRC has been supporting an important sorghum improvement program at the College of Agriculture in Dire Dawa. Among a number of improved varieties, the Ethiopians have identified two particularly high-yielding cultivars that provide yields 7–10 times greater than the national farm average of approximately 1 ton per hectare. More than 60 genetic lines that appear well adapted to the high altitude conditions have been identified and crossed with others having other desirable characteristics.

Since Ethiopia is the original "home" of sorghum, it provides a valuable source of germ plasm, including wild and domestic varieties that have never before been examined and classified. The protein of conventional sorghums tends to be deficient in the essential amino acid, lysine, containing between 1.8 and 2.0%. Among the native Ethiopian varieties several have been found with lysine content higher than 3% and these are now being distributed and crossed with other sorghums in many parts of the world to bring about an overall improvement in the nutritional quality of the sorghum grain.

Elsewhere in East Africa, at Serere, Uganda, improved varieties of sorghum and millet are being developed and tested both locally and by farmers in other East African and Middle Eastern countries. These include varieties resistant to attack by birds, which perhaps cause more damage to cereal grains than any other pest except the locust. As in most other projects supported by the IDRC, much of the work in this East African Community project has been undertaken by graduate students working for higher degrees.

Two projects involving intercropping of sorghum with legumes are underway, at Makerere University in Uganda, and at the University of Dar es Salaam in Tanzania. Initial results clearly indicate that combinations of sorghum or millet with legumes give considerably higher yields per unit of land than either crop grown separately. A demonstration of these results to political leaders and government officials by the Tanzania scientists impressed upon them the importance of multiple cropping systems in a country where until recently mono-culture had been officially encouraged. And at the University of Nairobi in Kenya graduate students are studying the influence of various cereal and legume crop combinations on yield, on weed and pest control, and on long-term soil fertility. Related research is also being carried out in Rwanda, Thailand, and Papua New Guinea, where sorghum is being intercropped with maize and sweet potatoes, and in Sri Lanka, where a major dry land crops research project is being supported.

In Mexico, considerable progress has been made in the breeding and selection of sorghums suited to high altitudes and low temperatures. In defiance of the conventional wisdom that sorghum would not set seed at altitudes above 2000 metres, the Mexican research has produced genetic lines that satisfactorily produce seed at up to 2500 metres. Eighteen countries are now cooperating in the high altitude sorghum improvement program, which is carried out by the International Maize and Wheat Improvement Centre (CIMMYT) in cooperation with ICRISAT.

Researcher examines frost-damaged sorghum in Ethiopia.





Research at the University of the West Indies results in improved pigeon pea crops.

Food legumes

In addition to their ability to survive and yield a crop under conditions of extremely low rainfall and to fix nitrogen from the air, the prime virtue of food legumes lies in the fact that their protein content is complementary to that of cereal grains. Combinations of maize and beans in Latin America, rice with soya or mung bean in Asia, sorghum with cowpeas in Africa, or wheat and chick-pea in the Near East are nutritionally superior to meals in which either the cereal or the legume is eaten alone. Yet such statistics as are available indicate that during the past 20 years per capita legume production in Asia and Africa has been declining while the proportion of cereal consumed has increased. This suggests that the nutritional quality of the diet of the poorest people may be deteriorating.

In an effort to correct this imbalance the IDRC is encouraging and supporting research to develop legumes capable of giving higher yields and improved nutritional quality in the semi-arid tropics. Since its inception the Centre has supported the chick-pea and pigeon pea

improvement program carried out by scientists at ICRISAT in Hyderabad, India. The purpose of the program is to breed and select for higher and more stable yields, higher protein content, and resistance to diseases and pests. The ICRISAT scientists have collected several thousand genetic lines of chick-pea and pigeon pea, and trained Indian villagers to combine the desirable properties of different lines by hand-crossing. In cooperation with ALAD, a nursery was also established in the Near East so that two experimental crops of chick-peas can be grown in every calendar year.

A Centre-supported project at the University of the West Indies concentrates mainly on pigeon peas and to a lesser extent on cowpeas. With the aim of improving the quality of food legumes grown in the Caribbean, the West Indian scientists have developed genetic lines that are short in stature, have compact branching, large pods and seeds, and significant resistance to several major diseases. By selection for appropriate characteristics they have made possible a far higher density of planting — in some experiments more than 20 times the density normal to the Caribbean.

Other food legume research projects are underway in Kenya and Sri Lanka, and a network of cowpea improvement projects is being formulated involving several West African countries, the International Institute of Tropical Agriculture (IITA) in Nigeria, and the International Fertilizer Development Centre (IFDC).

The predominant crop in Asia: rice trials at IRRI.



Rice and Related Crops

The research supported by the Division in this field falls into two categories: first, support for multiple cropping and cropping systems in a number of Asian countries where rice is the principal subsistence crop; and second, for the improvement of the rice crop grown on irrigated lands along the principal rivers of West Africa.

Multiple cropping in Asia

Multiple cropping can be generally defined as "growing more than one crop in the same year on the same piece of land," and includes intercropping (growing two or more crops simultaneously), relay cropping (planting a second crop before the first is harvested), and sequential cropping (planting crops before and/or after the normal cropping season). Because rice is the principal food crop in many Asian countries, any improvement must be centred on a predominantly rice-based agricultural system — and this is reflected in the work of the International Rice Research Institute (IRRI) at Los Banos, Philippines.

In addition to programs devoted exclusively to rice production, the Institute, with the support of IDRC, operates a broad-based cropping systems program to study basic principles and develop and test new component technology and its application in improved cropping systems as a means of increasing the production and nutritional quality of food in South and Southeast Asia. Through a closely linked project network, IRRI is backing national agricultural research institutions to develop their own adaptive cropping systems research programs to speed the adoption of improved cropping systems by farmers.

After several years of experimentation the IRRI program and associated country programs are now providing strong evidence of the increased production that can be achieved through appropriate intensification of cropping systems. By various combinations of corn, sorghum, legumes, and vegetable crops with and around the main rice crop, yearly total production on a given piece of land can often be doubled. Direct seeding techniques for planting rice and new varieties with shorter growing seasons have made it possible to grow two crops of rice instead of one and/or include upland crops as well. At one trial site a farmer obtained a yield of 6.2 tons of rice per hectare from two crops whereas most farmers were getting only 1.3 tons from a single crop. At another site in the Philippines yield from two rice crops ranged from 7 to 10.2 tons per hectare compared to the 2–4 ton yields normally achieved in the area.

Intercropping can prove beneficial in controlling weeds and insects and reduce the cash investment for farmers who cannot afford large inputs of chemical insecticides and weed controls. In a maize with mung bean intercrop trial, for example, the maize yield actually increased by 18% over maize grown alone as a result of the restriction of weed growth by the mung bean plants. Intercropping maize with peanuts more than halved the number of plants infested with stem borer in another experiment.



Impressive multiple cropping experiment at IRRI.

A good deal of the research has taken place on farmers' fields with their input to ensure that the results are in fact adjusted to actual levels of resource availability and management capabilities. Where cropping patterns and systems have thus been adjusted to farmers' actual situations they have been readily taken up by farmers associated with the research program as well as others in the pilot research areas. IRRI is currently evolving a system and methodology through which country research and extension programs can quickly arrive at recommendations for cropping systems tailored to provide the best return possible within individual farmers' particular financial and other constraints.

At IRRI's request IDRC has provided support for an outreach project being undertaken by scientists at the University of the Philippines, Los Banos (UPLB). Complementing the cropping systems research at IRRI, the project is evaluating genotypes of crops suitable for multiple cropping in Asia received from several IARCs and national research institutions. Superior varieties are then tested in differing agroclimatic zones to determine the range of their adaptability as components of improved cropping patterns.

In the course of their research into cropping systems, IRRI workers discovered that crops planted following mung beans or cowpeas produced unusually low yields. Again at IRRI's request backup research is under way at the University of British Columbia to investigate the possibility that mung bean and cowpea release chemical toxins into the soil that are deleterious to subsequent legume crops.

Indonesia is the site of another cropping systems outreach project. The aim is to develop and adapt systems for rainfed and partially irrigated rice areas, both at research stations and through cooperative farm trials. The project also has an important training element, with research and extension workers being prepared for participation in cropping systems programs.

At the Bangladesh Rice Research Institute (BRRI) researchers are using IRRI's results as a basis for studying present cropping systems to recommend more efficient land use systems in the varied agroclimatic zones of Bangladesh. This project is also providing training for agricultural workers and information and demonstrations for farmers in the project areas.

At UPLB researchers are evaluating the ability of rural communities to sustain the accelerated rates of production resulting from an intensive cropping systems program operated for some time in association with IRRI. Some 24 villages were initially involved in the project, representing many different agricultural production systems, and some are now functioning independently. The success of the program is evidenced by the increased number of farmers undertaking multiple cropping. On average the percentage of land double-cropped in the original project villages has doubled, and the number of participating farmers has risen from 29 to 490. The number of farmers borrowing from credit funds in the village banks rose by 800% in two years as the program began to take effect. Further evidence of the project's success is the recent adoption by the Philippines Department of Agriculture of the project's approach and organization for testing in one entire province plus 20 other municipalities scattered throughout the country.

The cropping systems network extends to Sri Lanka, where researchers are studying rainfed and tank-based irrigated and partially irrigated cropping systems in the intermediate and dry zones of the country. The project is also evaluating improved varieties, irrigation practices, and cropping systems in farmers' fields, and once again training is an important integral part of the overall program.

The increased pressures of population growth in Asia make the more efficient use of available farmland and other resources a priority, and one that requires innovative approaches such as the cropping systems outlined here. By "plugging into" IRRI's closely linked project network, the Division is able in a small way to encourage and support the development and rapid implementation of such systems.

Rice research in Africa

The demand for rice in West Africa continues to outstrip production in the region, necessitating imports totalling \$250 million annually. Yet the former Director-General of IRRI, who IDRC retained as a consultant on rice development in West Africa, predicts that many of the more productive rice varieties, together with some of the multiple cropping systems developed at IRRI, can be successfully adapted to irrigated conditions in the region, with resulting significant increases in food production.

IDRC is now supporting research to improve production of irrigated rice by the West African Rice Development Association (WARDA), which was created in 1970 with the express purpose of making West Africa self-sufficient in rice. Since efficient water management will be a major factor in the economic success of rice production in the region, the project began with a study of water management by a group of experts meeting in Senegal. Both IRRI and the Nigeria-based IITA are providing technical support and training facilities for the African scientists engaged in the project.

Traditional rice-threshing techniques: it's a family affair.



Triticale

One of the largest research programs undertaken by the Division since its formation has involved the development of triticale — a new cereal grain resulting from a cross between wheat (*Triticum*) and rye (*Secale*). Since much of this work has already been documented at length in other IDRC publications (see Appendix 1) and elsewhere, this section attempts no more than to present a few highlights of the program.

The triticale program began in 1971 when the Centre entered into a contract with the Canadian International Development Agency (CIDA) on the one hand and with CIMMYT and the University of Manitoba on the other. The University of Guelph joined the project later. Throughout its life the program has been guided by an Advisory Committee composed of two scientists from CIMMYT, one from each of the cooperating Canadian institutions, and three independent scientists.

The aim of the program has been to produce a highly nutritious cereal grain that would outperform the traditional cereal grains in terms of yield and tolerance to adverse factors such as sandy or acid soils, high altitudes, and low temperatures.

At the outset it was agreed that the cooperating partners would seek to create a wider genetic variability in triticale as a means of increasing yield, to improve seed quality by eliminating shriveling (a characteristic of wide intergeneric crosses), to overcome lodging by introducing a shorter stronger straw, to improve resistance to various diseases such as rust, smut, and ergot, and to breed and select triticales adaptable to a wide range of agroclimatic conditions.

The overall progress made during the program's first five years is best illustrated by comparing the state of the art in 1970 with results from the 1975 crop. In 1970 only one new triticale plant was successfully produced by embryo culture — by 1973 chromosome doubling had been achieved in some 3200 cultured plants. In 1970 both the yields and the test weights of the 10 best triticales were significantly lower than those for the 10 best wheats grown at CIMMYT — by 1975 the yield and test weight for triticale was 7896 kg/ha and 77.5 kg/hl respectively, compared to 7600 kg/ha and 85 kg/hl for wheat. Fertility in the newest triticales has reached 92%, approaching the 97% achieved by CIMMYT wheats.

The CIMMYT scientists now believe that inheritable fertility is no longer a cause for major concern. Excessive tallness and lodging have been largely offset by the introduction of dwarfing genes from wheat and rye, and the best triticales are now more resistant than wheat to a number of rust diseases.

Susceptibility to ergot, a matter of some concern with early varieties, is being vigorously tackled at the University of Manitoba, where scientists are seeking to identify resistant strains of triticale, spring and durum wheats and to determine the variability in virulence of various ergot fungi. The Manitoba pathologists have isolated some 30 of the most virulent ergot strains and have identified varieties that are resistant to all of the most virulent ergots and several others that exhibit good resistance to most of them.

Triticale yield and selection nurseries have been established in more than 65 developing countries and IDRC is financing cooperative breeding, selection, and adaptability projects in India, Ethiopia, Lebanon, Algeria, and Kenya.

Certain marked trends are already apparent. Triticales appear more productive than wheat on sandy soils and at high altitudes, and are more tolerant to frost and to soils that are acid or high in aluminum. In Brazil triticale thrives at six times the level of soil aluminum tolerated by the best wheat. In India work on farms and test stations in the Himalayas at altitudes between 2000 and 3000 metres shows that in all cases triticale performs better than wheat in terms of both yield and protein content. The same is true at high altitudes in Ethiopia and Chile. In Kenya triticale yields have greatly surpassed those of wheat on marginal nutrient-deficient soils. In Chile, yields of nearly 13 tons per hectare have been reported from irrigated experimental plots.

The average protein content of the triticales appears about 1% higher than the average for the world wheat collection, and a number of genetic lines have been found with lysine content in excess of 4% of the protein, thus providing a cereal grain significantly higher in protein quantity than, and equal in nutritional quality to "high-lysine maize."

In short, although there are still hurdles to be overcome, the potential of triticale as a nutritious cereal crop that will thrive on marginal lands under conditions ill suited to wheat and other major cereals is well on the way to being fully realized.

IDRC's Information Sciences Division supports, through CIMMYT, the publication of a quarterly abstract of current triticale literature produced by the Commonwealth Agricultural Bureau (CAB). A quarterly triticale newsletter for research workers is also planned. The Division has also reviewed and published in book form the nutritional quality of triticale in comparison to its parents wheat and rye.

Triticale, the first successful "man-made" cereal grain.





Smallholder farmer in the Caqueza district of Colombia.

Crops Research for High Altitudes and Marginal Lands

The bulk of the Division's work in this field has been concentrated on the Caqueza project, an integrated program of rural development that aims at improving the lot of smallholder farmers in the Caqueza district of East Cundinamarca province in Colombia. One of the first projects to be approved by the Centre's Board of Governors, it proved over a five-year period to be one of the most diverse and interesting.

The project, carried out by the Colombian Agricultural Institute (ICA), essentially entailed a detailed study of agricultural practices, and how they might be improved, on the small farms of the region. In practice it evolved into a program that involved not only the farmers but also their families and the entire community, and dealt not just with agriculture but also with some of the social and economic problems of the region.

The Caqueza district is in a mountainous area containing some 12 000 farms, most of them of less than 3 hectares. The principal crops are maize

and potatoes, depending on altitude, and both are traditionally grown in combination with various kinds of legumes, squash, and other vegetables — perhaps as many as 11 crops in the same field at the same time. About 80% of total production is consumed on the farm, and the average family has five or six children and an income, including the value of produce from the farm, of about \$700.

Against this background ICA developed improved systems for the two principal crops over the first two years, and these were tested by the farmers themselves. Many farmers were reluctant, however, to invest in experimental cropping systems for the simple reason that they had no risk capital — if the experiment failed their families would go hungry. To overcome this problem the project team developed a risk-sharing credit plan to operate through the local farmers' cooperative. With this guarantee against losses, 95% of the farmers in the project area adopted the new technology, and the program moved into the improvement of vegetable crops as well.

An important component of the Caqueza project has been a large-scale training program. Some 35 young Colombians have carried out thesis research on different aspects of the overall project, and at the training centre established near the project headquarters, 425 Colombians have undergone intensive short courses in on-farm operational research with small farmers.

Perhaps the most important single fact to emerge from the project is that peasant farmers are highly efficient in the use of their resources but that this efficiency can be improved once the constraints that hold them back from utilizing more capital-intensive technology have been identified and overcome.

The project has involved not only a large membership of the peasant farming community but also the research and extension services of the Ministry of Agriculture and a variety of other agencies, including the National Planning Agency, all of whom have gained a much better insight into the opportunity for small-farm development, and in particular the human motivational factors that influence the transfer or adoption of new technologies. This has resulted in a marked change in attitude to small-farm development in Colombia, with an increased emphasis being given to facilitating credit and assisting marketing. Equally important has been the greater integration of effort among all of the agencies concerned, and as a result the project has given rise to significant technological and institutional change in Colombia, and provides valuable lessons for other developing countries facing similar problems.

Although maize and potatoes are known throughout the world, there are other crops indigenous to the high Andes that are almost unknown elsewhere and have received comparatively little research attention. These include the chenopods, some of which are believed to be among the most nutritious grains in the plant kingdom. The Division is now supporting research into the development of one of these crops, quinoa, which is of special interest since it is widely cultivated in the Andes, is an excellent source of nutrition, and, if its yields can be increased, could help to reduce costly dependence on wheat imports in several Andean countries.

Cassava

The cassava research network is probably the most comprehensive of all the research networks supported by IDRC. The Centre has allocated \$4.1 million in support of various cooperating projects and complementary activities, this in addition to managing funds supplied by CIDA, for an international cassava research program.

Cassava — also known in different parts of the world as manioc, mandioca, tapioca, and yuca — is an important food source for more than 300 million people in the humid tropics of Asia, Africa, and Latin America. Yet until fairly recently cassava had received relatively little attention from the scientific research community. One of the first actions taken by IDRC was to screen world literature and to bring together all the principal research workers who had been or were involved with cassava research in various parts of the world.

As in the case of the triticale program, an Advisory Committee was formed composed of two members of the staff of the International Centre of Tropical Agriculture (CIAT), which became the headquarters for the cassava research network, plus representatives of other participating institutions and two independent experts. Also as with triticale, the progress of the cassava program has been extensively documented in a number of other IDRC publications, and what follows is merely a summary.

Although the main thrust of the research undertaken at CIAT has been on the identification and development of superior germ plasm capable of giving high yields under a wide range of ecological conditions, the program is widely interdisciplinary, and covers all aspects of cassava development.

In supporting programs considerable attention has been given to the identification and control of cassava bacterial blight, to various fungal infections, and to cassava mosaic disease, which, although unknown in Colombia, is a major problem in Africa and India. Four major pests of

Simple cassava grafting technique developed by an Indonesian farmer.



cassava are also being studied in detail, including hornworm, shoot fly, thrips, and spider mite. Weed control, a major cost factor in cassava production, is also being studied, especially in relation to multiple-cropping practices. The CIAT soils program is identifying the major nutrient requirements of cassava and studying methods of correcting minor element deficiencies in the field. Economics research is providing basic information on resource allocation, studying new technologies, and furnishing data on marketing methods and overall policy to national agencies. Two cassava storage systems have also been developed at CIAT.

As information from the research program has grown, CIAT has developed both long-term and short-term extensive training programs in collaboration with a number of Latin American and Asian countries, with the objective of helping to strengthen their national research efforts.

There is heavy emphasis on training in two CIAT outreach projects that bring together several countries in Asia and Latin America under regional coordinators to conduct applied research on cassava, and to ensure that useful results are made available promptly to the cassava producers themselves, especially to small farmers.

In Africa, IDRC is supporting research at IITA on the biology of causal agents and the epidemiology of cassava bacterial blight. In Indonesia a research team is studying the potential of a high-yielding "tree cassava" produced by a simple grafting technique developed by an Indonesian farmer. Malaysia is also building a cassava research program, and through extensive on-farm trials is determining the varieties and agronomic practices best suited to Malaysian agroclimatic conditions. A comprehensive program to strengthen and broaden the cassava research capacity of India's Central Tuber Crop Research Institute (CTCRI) and to establish techniques for disseminating research results to small farmers is under way in that country. The Trinidad station of the Commonwealth Institute for Biological Control (CIBC) is cooperating with Uganda to develop a means of naturally controlling the green spider mite, a cassava pest that has recently appeared in East Africa. In all these projects, training, with the objective of developing an ongoing capacity for cassava research, is an important element.

In Canada, research supportive of the CIAT program is being undertaken at the University of Guelph, Ontario, at McGill University in Montreal, and at the Prairie Research Laboratory in Saskatoon.

The Centre itself is providing direct support for several aspects of the cassava network. The Health Sciences Division is supporting a project in Zaire concerned with cassava toxicity, while the Information Sciences Division supports the cassava documentation centre at CIAT, which has the world's most extensive collection of cassava literature. The AFNS Division has supported numerous international workshops for cassava research workers, and sponsored the International Society of Tropical Root Crops (ISTRC) triennial symposium, in addition to meetings of the Cassava Advisory Committee. An integral part of such activities is the publication of proceedings and the distribution of these reports to concerned scientists, most of this being coordinated by the Centre's Publications Division.

Animal Sciences

It is sometimes suggested that support for animal research should be discouraged, since it is more efficient both biologically and in terms of land use to feed plants directly to humans rather than through intermediate animal products. Though land suited to the efficient production of cereal grains and legumes is best not turned over to animal production, the above argument ignores the fact that animals serve a useful role in the food chain through their ability to convert a wide range of agricultural by-products and other wastes unsuitable for direct human feeding into milk, eggs, and other animal products. On this basis the Division is supporting several projects related to improved animal production in developing countries with an emphasis on three areas of research: utilization of by-products, improvement of pasture lands, and control of animal diseases.

By-product Utilization

Several projects in this category are concerned with the use of cassava in animal feed. At the University of Ife in Nigeria scientists are studying the biological efficiency of various feed formulations for ruminants, poultry, and swine. These include cassava, oilseed meals (by-products of vegetable oil production), and other protein sources such as the leaves from cassava and other local plants. The results obtained so far indicate that leaves can provide a satisfactory source of protein in animal feeds in which cassava serves as the main energy source. This is an important finding in that, so far, no technically and economically feasible process of producing leaf protein for human consumption has been demonstrated.

Two related and complementary projects are in progress to develop and test cassava feed formulations for swine and poultry at Khon Kaen University in Thailand and at the University of Malaysia. In poultry-feeding experiments in Thailand, cassava meal satisfactorily replaced 50% of the usual maize ration. The Malaysians are developing methods of enriching cassava for animal feeds by the microbial conversion of cassava starch combined with inedible sources of nitrogen. They hope to develop processes and feed production technologies suitable for use under rural conditions in the region. Tests have produced an enriched cassava substrate with a protein level of over 10%, which has been used as a substitute for the usual cereal grain content in feed for swine and poultry.

At the Institute for Nutrition for Central America and Panama (INCAP) considerable progress has been made in developing waste coffee pulp — a fleshy material surrounding the so-called coffee bean that, although high in protein, is usually thrown away — as a protein source in animal rations. One of the obstacles to the use of coffee pulp is the



Poultry on an experimental cassava diet at Khon Kaen University, Thailand.

presence of caffeine and other phenolic substances that seem to impair the nutritional value of the protein present. Researchers in Guatemala and neighbouring countries are attempting to eliminate or neutralize these antinutrients so that the animals may derive the full benefit of the protein content. Several techniques are being tried to reduce the adverse effects of the inhibitors, and it is also possible that the caffeine extracted in these processes may become a marketable product through sales to pharmaceutical industries — in effect a by-product of a by-product. The dried coffee pulp can then be pelletized for use in animal rations at a cost of about one-third that of the plant proteins it would replace. The technical and economic feasibility of the use of this by-product is now being tested in cooperation with a number of animal producers in the region.

In Mexico a number of research and government institutions are cooperating to develop cattle-feeding systems that can make use of sugar cane and cane by-products, and thus reduce the dependence on imports of both milk powder and cattle feed supplements. The aim is to make more efficient use of low-grade sugarcane and the cane by-products of sugar refining. Chopped cane combined with molasses, urea, and rice polishings has produced acceptable cattle growth rates at considerable savings, and for milk production further cost reductions are being achieved by substituting a legume, *Leucaena leucocephala*, for half of the rice polishings in the ration.

Pasture Improvement

There are many parts of the developing world where the soil and climatic conditions, although unsuitable for intensive crop production, will support pastures for grazing animals or combinations of food crop and animal production. The most productive pastures, however, do not often occur naturally, and considerable scope exists for research to determine the optimum and most productive combinations of grasses and other edible feed crops.

In the Caribbean, scientists at the University of the West Indies are carrying out research on pasture improvement and management in Belize, Antigua, and Trinidad. The general objective is to determine the productivity and pasture quality of indigenous and imported exotic pasture legumes, either alone or in combinations. During the first phase of the work several hundred different species and varieties of pasture legumes have been collected and screened for yield and growth characteristics under a wide range of agroclimatic conditions. Particular attention is being given to the relative ability of the pasture legumes to fix nitrogen from the air and to determine their resistance and competitiveness when subjected to animal grazing. The research is being carried out both on experimental plots and on small commercial farms.

A related and complementary project is in progress at the Mexican National Agricultural Institute (INA), where a methodology is being developed to serve as a model for forage research both for Mexico and for other Latin American countries. The improved forage systems are being tested not only at the research station, but on local farms. Several graduate students are receiving training through the project in the fields of forage production and utilization.

Livestock Diseases and Management

The Centre is financing a research team at the East African Veterinary Research Organization (EAVRO) at Muguga in Kenya that is attempting to obtain a better fundamental understanding of the important cattle diseases trypanosomiasis (sleeping sickness in humans) and theileriosis (East Coast Fever), both of which cause severe wastage among African cattle. As in other projects there is a heavy emphasis on the training of Africans in essential research methodologies and techniques. Several are working toward advanced degrees by taking their basic training at the University of Guelph in Canada (which is also supporting the project) and their practical thesis research in Africa.

The trypanosomes, protozoa that cause trypanosomiasis, are conveyed to the cattle by the tsetse fly. It is believed that reservoirs of infected trypanosomes are to be found in wild African game, which have developed an immunity to the diseases not shared by the imported breeds of cattle husbanded by African farmers.

Already the project has thrown new light on the nature of trypanosomiasis, and it is believed that one of the important toxins that



Diseased goats are studied by researchers at EAVRO in Kenya.

gives rise to many of the undesirable symptoms 'has been identified. Studies are continuing on the clumps of trypanosomes that are formed in the small blood vessels, particularly of the brain and the heart, and cause severe injury to the host. Techniques are being developed to disperse these clumps and to count the number of trypanosomes present, and thus determine in any animal the severity of the infection. Progress has also been made in gaining a better understanding of the anemia characteristic of trypanosomiasis that appears to be caused by a destruction of the red cells rather than an inability of the infected animal to manufacture new cells.

In the field of livestock management the Division has provided substantial support to CIAT's swine outreach program in Latin America. Animal scientists from several countries were given intensive training at CIAT in swine production and management and then provided with funds by IDRC to return to their own countries to establish regional centres for research, training, and demonstration.

Fisheries

Because there is no international centre devoted to fisheries research, this program consists of support from a series of projects in several countries of Africa, Asia, the Near East, and Latin America, and the development of networks of research projects among developing countries. Fisheries research supported by the Division falls into four general categories: the broad field of aquaculture or "fish farming"; artisanal fisheries on the West African coast; improved fish processing systems; and the utilization of neglected fish species.

Aquaculture

Aquaculture involves the controlled breeding and husbandry of both freshwater and saltwater edible fish species, and has long been a traditional practice in Asia. Given the extraordinarily large volume of inland waters that are considerably understocked, the opportunities for increasing world protein supplies through aquaculture are yet to be realized. But little has been invested in research in this field, and because of the much greater complexity of the problem the rate of progress in research is much slower than in, for example, crops research. Comparatively little is known about the nutritional requirements, life patterns, susceptibility to disease and predators, or optimum environmental conditions for many of the fish species capable of being cultivated. The problem is compounded by the fact that few universities offer training facilities in science related to aquaculture.

The Division, both by its support for a network of aquaculture projects and by the participation of its staff members in international study groups on aquaculture research, has encouraged the considerable expansion that has taken place in this field, particularly in the developing countries of South and Southeast Asia.

One of the major obstacles to increased fish production in Asia was defined at a regional aquaculture workshop sponsored by the Division — the shortage of fish seed and young fry with which to start fish ponds. Many fish that deposit large quantities of eggs in their normal habitat do not reproduce effectively in captivity. The less developed countries of Asia do not produce nearly sufficient seed to meet present requirements, and if the full potential of aquaculture is to be realized, the establishment of adequate seed banks is a major priority.

Captive fish can be induced to spawn through injection with hormones such as the gonadotrophin derived from the pituitaries of the salmon. At the freshwater fisheries research station of the Malaysian

Agricultural Research and Development Institute (MARDI) the Division is supporting a project to develop standard procedures for bulk production of fish seed by induced breeding of carp and other important species. The researchers are also investigating local sources of fish gonadotrophin as a replacement for the hormone derived from the pituitaries of Pacific salmon.

Similar studies of induced breeding techniques are being carried out with IDRC support at the Southeast Asian Fisheries Development Centre (SEAFDEC) in the Philippines as part of an overall program for the development of milkfish. It is estimated that improved technology could double or even treble the yield obtained by the traditional method of catching the fry in nets and transferring them to ponds. The SEAFDEC program is the largest fisheries project supported by the Division, and one of the few international aquaculture research programs. SEAFDEC was created to promote fisheries research in Southeast Asia, and is supported by 10 countries from the region. It has a sizeable training program, including some 45 graduate students, and offers a short intensive training course for aquaculture research workers who are involved in cultivation practices, hatchery and pond management, feeding systems, and other relevant subjects. SEAFDEC will ultimately serve as a regional resource, information, and coordination centre for aquaculture throughout South-east Asia.

At India's Central Inland Fisheries Research Institute (CIFRI), scientists have demonstrated under experimental conditions that large yields can be obtained from composite aquaculture, in which as many as six different species are farmed together in the same body of water. With IDRC support CIFRI is now testing these experimental systems on a number of village aquaculture farms to see how they stand up to the conditions that prevail among rural communities.

Working with the rural communities, the Indian scientists are also studying the control of diseases and parasites, how the fertility of the waters can best be maintained, the nutritional and environmental requirements of the different species, management techniques, the best means of transporting the young fry, and other problems that arise from the village studies.

In Indonesia the Inland Fisheries Research Institute (IFRI) is studying the life cycle of important parasites in an attempt to identify vulnerable stages of development at which they might be attacked and destroyed. The Indonesian scientists are also exploring the treatment of young fish with chemical dips that may be effective against parasites at an early stage of development. The project scientists are also examining the effect on cultured fish of toxic agricultural chemicals.

In Sarawak, Malaysia, the Division is supporting a systematic study of the principal species of fish present in natural lakes and rivers to determine such factors as the proportions of prevalent species, rates of growth, and to identify the most promising species for aquaculture. In addition to providing valuable information for aquaculturists, the research should provide useful data on which to base regulatory measures for the conservation of important species and better overall management of the vast resource of inland waters.

Although wild oysters and other shellfish are an important food source for many people in developing countries of the tropics, comparatively little research has been carried out to increase their productivity. Results from two tropical oyster-culture research projects supported by the Division — one in Sabah, Malaysia, and one in Sierra Leone — demonstrate that tropical oysters can reach a marketable size in about one-fifth the time required by oysters produced in temperate climates.

In Sierra Leone experiments with raft and tray culture produced oysters with four times the volume of the wild species harvested from mangrove roots, with marketable size being reached in just six to eight months. In Sabah, West Malaysia, studies are being undertaken to determine the best areas and conditions for oyster-culture, the most practical and economic methods of production, and the means by which to establish a seed supply station. Both projects are also studying such factors as processing, marketing, and hygiene, and include a training element for local people.

Oysterculture in Sierra Leone, using a simple raft of bamboo and oil drums.



Artisanal Fisheries

Ghana is a net importer of more than 100 000 tons of fish a year, in spite of the fact that fishing from canoes and other small boats is the major occupation in the coastal areas not only of Ghana but also of many neighbouring countries. In Ghana the Division is supporting research to improve the standard of living of some 70 000 families along the coast who derive the bulk of their income from artisanal fishing.

Undertaken jointly by two universities, the Fisheries Division of the Department of Agriculture and the Food Research Institute of the Council of Scientific and Industrial Research, the project is being carried out in cooperation with the fishermen of the Central Region. It has led to a number of improvements in traditional fishing techniques, such as modification of the nets and how they are used for trawling, and some modifications to the design of the boats. Lobster pots of improved design have also been developed and introduced. Comparative studies have been made of different types of fish-smoking ovens, and an improved model is being tested in a number of villages. Improved techniques for salting and sun-drying the fish have also been well accepted by the women, who traditionally process and sell the fish caught by the men. Research is now in progress to reduce breakage and infestation of dried fish and to develop better methods of packaging and distribution so that fish can also be made available to the people farther inland.

Finally, a group of economists is studying the financial aspects of the project. Since few alternative employment opportunities exist for the fishermen and their families, and since there is an overall shortfall in fish supplies, this project can be of significant benefit for the people of many West African coastal nations.

Fish Processing and the Utilization of Neglected Species

The continental shelf off Guyana is the centre of a large shrimp fishery that employs more than 500 modern shrimp trawlers. These trawlers also harvest large quantities of what are generally termed "trash fish," but which in fact include large numbers of edible species. Unfortunately most of this by-catch is simply jettisoned at sea. However, the government of Guyana now requires that trawlers using the port of Georgetown land at least a part of the by-catch in order to increase the food supply for the people of the region.

Several Guyanese organizations are cooperating in a project financed by IDRC that is classifying the various species in the by-catch to determine their nutritional and economic value. The most important component of the project is to develop inexpensive methods of processing and preservation, including salting and smoking, and the production of acceptable minced-fish products. Attention is also given to more expensive fresh- and frozen-fish products for the export market and Caribbean tourist hotels, and work is going ahead to produce a variety of novel fish products — including fish sausages made from minced shark — to be used as nutritional supplements in local diets.



Developing inexpensive methods of fish processing in the Guyana project.

Inadequate storage and handling results in considerable waste of fish through spoilage throughout much of Southeast Asia. At a regional workshop on stable tropical fish products sponsored by IDRC, scientists of the region took the first steps toward establishing a program to improve the situation.

The first project to arise as a result of this workshop is being carried out by the University of the Philippines in cooperation with the Federal Bureau of Fisheries and Aquatic Resources and the rural fishing community. The project will study six important local species — milkfish, catfish, anchovy, herring, mackerel, and squid — with the aim of improving traditional methods of preservation. The purpose of this research is to develop standardized procedures, standards of quality and sanitation, and improved packaging, handling, and distribution.

The University is also developing prototype processing and packaging equipment from local materials, while the Bureau of Fisheries will establish pilot plant and demonstration centres at eight main rural fishing ports in addition to 70 field outposts to encourage the rapid adoption of the improved processes by the fishing communities. Another objective is to establish central cooperative units to which fishermen can bring their surplus fish for processing to more stable and attractive forms.



Acacia senegal seedlings: they will provide both shade, shelter, and gum arabic.

Forestry

As is the case with fisheries, there exists no international centre for forestry research. IDRC has sponsored meetings between Centre staff, consultants, and forestry experts as part of a project for the identification of tropical forestry research priorities. The aim is to identify gaps in world forestry research and training, and to suggest the best means by which the Centre and other international agencies can contribute to the improved management and utilization of forest products in the developing countries.

The Centre's present forestry program, which has been in operation for more than five years, concentrates on three major areas: savanna forestry, particularly in the Sahelian region of Africa; forest product utilization; and agrisilviculture, the combination of agriculture with forestry.

Savanna Forestry

The largest component of the forest research program is to be found in the semi-arid regions of Africa. A series of workshops for directors of forestry from countries of the region resulted in a cooperative network now involving 15 projects. The project directors meet each year to review their individual progress and to share their experiences.

In Nigeria the value of shelterbelts in improving agricultural production and the local environment is being studied, and researchers are carrying out species trials to select trees most suited for use in shelterbelts. Complementary work is being carried out in Sudan and Egypt, where large areas of once fertile farmland have been rendered useless through blowing sand covering the topsoil. In Sudan the project team is testing shelterbelts of mixed trees and bush species and studying the effects of the belts on the microclimate and the water economy within the protected areas. Egyptian scientists at the University of Alexandria are studying the casuarina, a species native to Australia, that has the added advantage of being able to fix nitrogen from the air. Thus, although it will provide shelter for farmland, it will not compete with the crops for soil nitrogen. The trees may also provide useful timber for building and other uses when they are thinned out in the normal course of shelterbelt management.

In Senegal two projects are being conducted by the Department of Water and Forest Resources. The first aims to restore forested areas to the savanna rangeland, particularly around waterholes, both to provide shelter for the herdsmen and their cattle, and to encourage the settlement of nomadic peoples in these areas. The second project is concerned with the species *Acacia senegal*, which is the primary source of gum arabic, an edible product widely used in the food and pharmaceutical industries. The

scientists hope to identify varieties of *A. senegal* and methods of silviculture that will provide the greatest yields of high quality gum. Approximately 25 hectares of seedlings from different sources have been planted each year during the last three years.

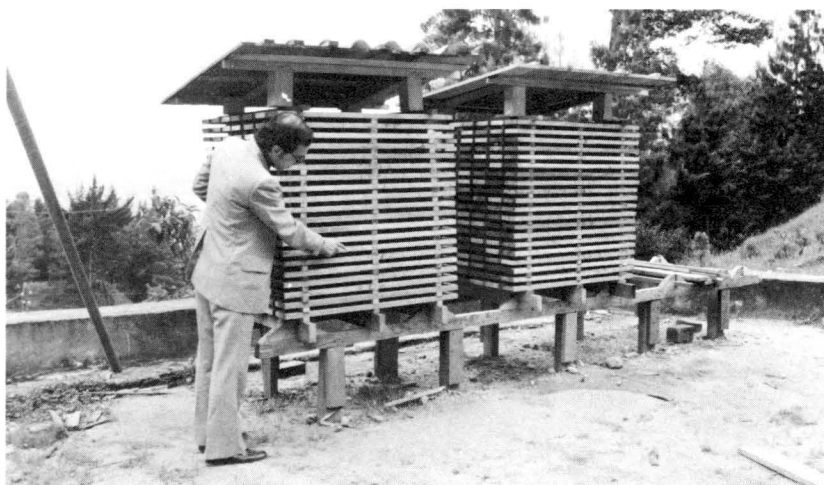
In Mali the Forestry Department, in cooperation with the Office du Niger, is studying the technical and economic effectiveness of developing irrigated forest plantations in association with crop production in areas close to the Niger River system. In Niger the Forestry Department is working with a number of village communities to establish village woodlots, owned and managed by the villagers, that will eventually provide them with a renewable resource of building materials and firewood. From seedling nurseries more than 100 hectares (over 80 000 trees) have been planted around 25 villages of the eastern region of the country. In Kenya there is a project to establish tree lots on farming communities where the land is not generally suitable for crop production, thus providing farmers with both shelter and an additional source of income. Trials are underway involving a large number of drought-resistant species under a range of agroclimatic conditions. And in Jordan scientists are attempting the reforestation of dry areas by planting trees in the ditches and wadis that carry runoff water from the brief but heavy rains. It is hoped that by establishing tree plantations in the areas of greatest soil moisture, much of the land can eventually be regained for the use of agrisilviculture.

Forest Product Utilization

It is estimated that probably less than 20% of the tropical forest is utilized effectively, largely because forest product industries tend to concentrate on a comparatively few lucrative species. The Division is supporting a number of projects to identify secondary and neglected species and other forest product resources that can be economically and productively used.

The largest single forest product research project supported by the Division is being undertaken by the Andean Pact group of countries in Latin America, and is directly concerned with the improved use of the secondary species of the tropical forests of the region. During the first phase some 100 timber species are being studied in a cooperative program that involves five national research institutions. In addition to a wide range of standardized laboratory tests and visual grading of the sawn woods, the Latin American researchers are studying such aspects as systems of jointing timbers derived from the various species for use in construction. They are also developing appropriate methods of drying and preservation, and critically evaluating the woodworking, machining, and finishing characteristics. The results of the research will be disseminated in the form of instruction and design manuals among the timber processing and utilization industries of the region.

A similar project is being undertaken on a small scale in Mali to improve the use of savanna timbers and increase their economic value to the sub-Saharan region. The project includes a study of the physical and economic properties of a number of local tree species that are being tested for strength and response to normal woodworking operations.



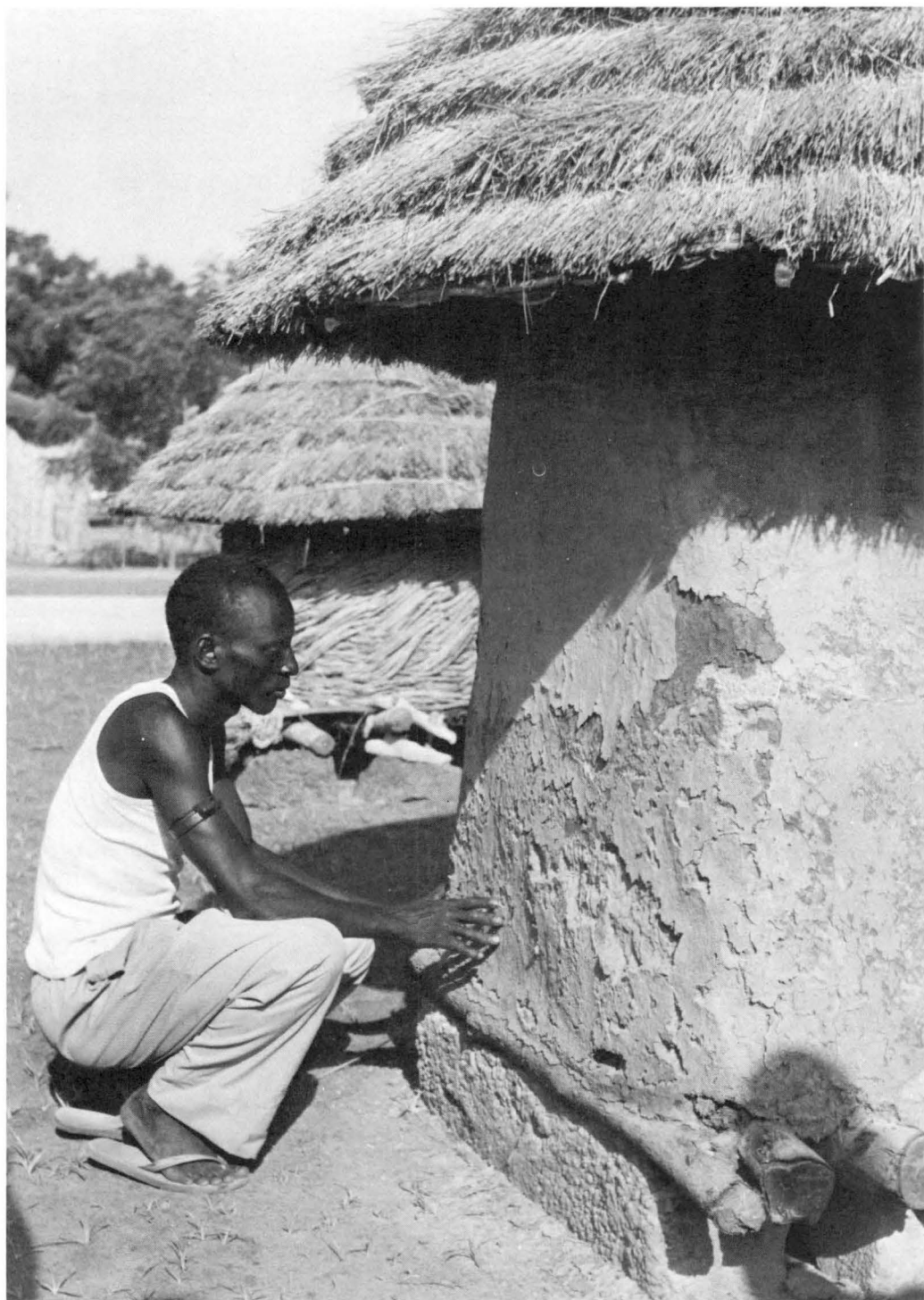
Open-air wood drying tests in Colombia, part of the Andean Pact project.

Agrisilviculture

Subsistence farmers in tropical forest regions traditionally provide clearings for crop production by cutting the trees with hand tools and then burning off the surface vegetation. In this process of slash-and-burn shifting cultivation, the soil rapidly loses its fertility, forcing the farmers to move on and clear more areas of virgin forest every few years. The deserted area is left to the natural incursion of weeds and brush. The Division is now supporting a cooperative program of agrisilviculture research in several countries of the humid African tropics to determine the most efficient systems of land utilization with trees and crops as a replacement for this traditional slash-and-burn process. The aim is to replace natural bush fallow with planted trees that will both restore the natural fertility of the soil and provide a useful timber resource for the rural forest communities.

The first project in this program is in Ghana, where scientists from the Council of Scientific and Industrial Research are studying crop and tree rotation. By comparing a number of rapid-growing potentially useful species, it is hoped to reduce the fallow period — usually 15–20 years under the traditional system — thus permitting a more frequent rotation of crops with trees. The project is receiving the cooperation and support of farmers and rural communities, who realize the need to make more efficient use of local resources as the population pressure on the land increases.

Several other projects have recently received Centre support, including one in Nigeria concerned with the effects of certain tree species on soil fertility, another in Cameroon dealing with leguminous tree and plant species, and a third at IITA that is investigating the possibilities of different combinations of crops and trees. The Centre is also supporting a proposal to establish an internationally funded agroforestry institute to coordinate and support research and extension projects on agroforestry systems and to disseminate technical information.



Senegal: traditional grain storage bin eroded by the rains.

Postproduction Systems

During its first five years this program has been largely concerned with cereal grains, grain legumes, and root crops. However, it is considered one of the most important areas for future development and support, and will likely expand to embrace other plant, animal, and fish products of importance to the subsistence and agricultural economies of the rural communities of the developing world.

The scope and complexities of the postproduction system include all the essential activities from harvesting until the end product, in whatever form, is eaten by the consumer. It therefore covers agricultural engineering, food science and technology, nutrition and household sciences, and all the basic disciplines of which they are comprised. In this area more than in any other, the Division has sought to create among the international community an awareness of the importance of the total systems approach to postproduction technology. There is a need for a better coordinated effort at all levels to deal with postproduction systems as a whole rather than tackling isolated problems in an ad hoc manner.

At the request of the CGIAR the Division undertook a study of postharvest systems research needs among the rice-producing nations of Southeast Asia and the cereal and legume producers of the semi-arid tropics.

The Asian study, which was carried out by the University of the Philippines in cooperation with several governments and institutions, led to the creation of a research support and advisory team to provide research and technical advisory services to all the interested rice-producing nations of the region. The team, which is based at the Southeast Asian Regional Centre for Agriculture (SEARCA), is guided by a Policy Committee comprised of senior officials from each of the participating Asian countries, and will help scientists and governments of the region identify and resolve problems related to rice postproduction systems.

In the semi-arid tropics of Africa a team composed of scientists from the University of Alberta and IDRC staff undertook a country-by-country study and organized several regional workshops to define the problems of postproduction systems related to cereal grains and food legumes, with a view to establishing research support service in Africa similar to the one established in Asia. The Division is also a member of the Group for Assistance on the Storage of Grains in Africa (GASGA), which seeks cooperatively to improve on-farm storage conditions for cereal and legume crops.

The importance of women's role in the processing, preservation, and marketing of farm produce is often underestimated and neglected in

developing countries. The Division has supported a number of studies in this field, including one by a group of African women home economists that resulted in the publication of a comprehensive book on the home preparation and use of cowpeas in West Africa.

One of the first postproduction systems projects in the program was undertaken by agencies of the federal and state governments of North and Northeastern Nigeria in cooperation with the University of Saskatchewan and the Prairie Regional Laboratory. This was the establishment in Maiduguri, Northern Nigeria, of a multipurpose pilot grain mill that has been operated and managed on a commercial basis by the local community in cooperation with the state government. The aim has been to establish both quality and process control and to encourage a market for local grains through the development of new food products in a test kitchen and bakery attached to the mill.

Projects concerned with various aspects of postharvest systems are underway in Senegal. In one, at CNRA, scientists have developed and compared the relative technical and economic efficiency of a variety of alternative methods of threshing, drying, storing, and milling sorghum, millets, and cowpeas.

A comparative study has also been made of alternative grain storage systems, including traditional bins constructed from locally available materials such as sorghum stalks, and more elaborate and expensive systems including metal drums, and various prefabricated concrete structures. Some innovative structures have been developed, one of the most successful being the silo magasin, which consists of a series of partitioned stores under a single roof, and can be used as a cooperative storage system for comparatively large quantities of grain.

Cleaning grain at the Maiduguri flour mill in Nigeria.



In Ghana, at Kumasi University, another comparative study is being made of grain storage structures, including butyl-rubber silos, galvanized steel and aluminum bins, circular plywood bins, low-cost ferro-cement bins, and plastic bags, both with and without chemical pesticides.

The Centre is supporting two projects in Botswana and Swaziland — both countries that must rely heavily on commercially milled maize flour imported from South Africa. They are, however, capable of greatly increasing their own production of sorghum. The purpose of the Botswana project is to produce in rural mills fine flour from locally grown sorghum that is as acceptable as the imported maize flour, while the project in Swaziland is concerned with the reduction of food losses through improved on-farm grain storage.

One of the most comprehensive postharvest technology projects supported by the Division is being carried out at five research institutions throughout India under the overall direction of the Indian Council of Agricultural Research (ICAR). The project is concerned with all the principal cereal grains and food legumes produced on small farms, and with all levels of the postharvest system. Because it is so comprehensive in scope, it is expected that the results will have important implications for many other developing nations, both in Asia and elsewhere.

A number of projects are underway in Southeast Asia as part of the cooperative network of rice postharvest technology research. In Thailand, government scientists are studying various aspects of the rice postproduction system, and in particular the practices adopted by subsistence rice farmers. In Singapore, government scientists are determining the storage conditions best suited to hulled rice, a study that includes both warehouse and home conditions. In Indonesia, a large study is being undertaken in association with 20 cooperatives in each of five regions of the country. The comprehensive program is examining almost all technological components of the total postproduction system under the conditions of the different regions.

One of the great difficulties faced by many of the rice-producing countries of Southeast Asia is the use of inappropriate technology. Methods of drying, storing, and milling rice that are appropriate for well-graded rice of uniform grain size harvested under comparatively dry conditions have proved totally unsuitable for the typically heterogeneous mixtures of many varieties harvested with very high moisture content throughout Southeast Asia. The overall purpose of the cooperative research network, therefore, is to study and develop technologies relevant to the needs of the region.

This same problem also applies to other crops. In the Philippines, scientists are examining the milling characteristics and relative nutritional values of different locally produced legumes and the use of legume flours in traditional foods. In addition they are developing low-cost processing technologies and simple processing methods. The project, which will eventually form part of a network similar to that for rice, is being extended to include both small-scale commercial processing and the processing of legumes in rural homes.

The Division is also supporting research into the processing of root crops, especially cassava. At the Asian Institute of Technology (AIT), in Thailand, scientists are determining the factors that control the rate and efficiency of drying of cassava chips and the pelleting of cassava flour for use in animal feed.

Research on the processing of cassava for both human and animal consumption is being carried out in a number of projects at CTCRI in India and in a large integrated cassava research project in the Philippines. The processing and storage of cassava is also included in several of the cassava research projects referred to earlier in the section on Crop Science.

In Peru the Division is supporting research into potato processing being carried out by the International Potato Centre (CIP) at La Molina in cooperation with the Institute of Food Industries Research. The objective is the development of village-level processes to produce acceptable dehydrated potatoes that can be stored over longer periods, thus reducing the large seasonal fluctuations in price. The techniques being explored include the use of osmotic and solar dehydration and the reduction of overall moisture content by a combination of potatoes with edible dry ingredients before solar or other dehydration.

Appendix 1

Related IDRC Publications

***IDRC-004e**

Osmotic dehydration: a cheap and simple method of preserving mangoes, bananas and plantains. G. W. Hope and D. G. Vitale. Ottawa, 1972, 12p.

***IDRC-010e**

Chronic cassava toxicity: proceedings of an interdisciplinary workshop, London, England, 29–30 January 1973. Barry Nestel and Reginald MacIntyre, editors. Ottawa, 1973, 162p.

***IDRC-015e**

Aquaculture in Southeast Asia: report of a seminar at the Freshwater Fishery Research Station, Malacca, West Malaysia, 17–25 April 1973. IDRC. Ottawa, 1973, 22p.

***IDRC-016e**

Consumer food utilization in the semi-arid tropics of Africa: report of an interdisciplinary workshop, Zaria, Nigeria, 30 April–4 May 1973. IDRC. Ottawa, 1973, 16p.

IDRC-017f

Durabilité naturelle et préservation de cent bois tropicaux africains. Yves Fortin et Jean Poliquin. Ottawa, 1974, 143p.

IDRC-017e

Natural durability and preservation of one hundred tropical African woods. Yves Fortin and Jean Poliquin. Ottawa, 1976, 131p.

***IDRC-020e**

Cassava utilization and potential markets. Truman P. Phillips. Ottawa, 1973, 182p.

IDRC-021e

Nutritive value of triticale protein. Joseph H. Hulse and Evangeline M. Laing. Ottawa, 1974, 183p.

***IDRC-022e**

Consumer preference study in grain utilization, Maiduguri, Nigeria. Jean Steckle and Linda Ewanyk. Ottawa, 1974, 47p.

IDRC-023e (revised edition)

Directory of food science and technology in Southeast Asia. E. V. Araullo, compiler. Ottawa, 1975, 267p.

IDRC-024e

Triticale: proceedings of an international symposium, El Batan, Mexico, 1–3 October 1973. Reginald MacIntyre and Marilyn Campbell, editors. Ottawa, 1974, 250p.

IDRC-026e

Food crop research for the semi-arid tropics: report of a workshop on the physiology and biochemistry of drought resistance and its application to breeding productive plant varieties, University of Saskatchewan, Saskatoon, Canada, 22–24 March 1973. Michael Brandreth. Ottawa, 1974, 16p.

*Available in microfiche only.

***IDRC-029e**

International Development Research Centre programs in agriculture, fisheries, forestry and food science: reviewed at a symposium, Ottawa, 12 September 1973. IDRC. Ottawa, 1974, 55p.

IDRC-031e

Cassava processing and storage: proceedings of an interdisciplinary workshop, Pattaya, Thailand, 17–19 April 1974. E. V. Araullo, Barry Nestel, and Marilyn Campbell, editors. Ottawa, 1974, 125p.

IDRC-033e

Interaction of agriculture with food science: proceedings of an interdisciplinary symposium, Singapore, 22–24 February 1974. Reginald MacIntyre, editor. Ottawa, 1974, 166p.

IDRC-036e

Current trends in cassava research. Barry Nestel. Ottawa, 1974, 32p.

IDRC-040s

Triticale: resúmenes de los ensayos presentados durante un simposio internacional, El Batán, México, 1 al 3 de octubre de 1973. CIID. Ottawa, 1975, 31p.

IDRC-041e

Stable tropical fish products: report on a workshop, Bangkok, Thailand, 8–12 October 1974. Marilyn Campbell. Ottawa, 1975, 27p.

IDRC-048e

To conquer hunger: opportunity and political will. W. David Hopper. Ottawa, 1975, 42p.

IDRC-048f

Vaincre la faim: atouts techniques et options politiques. W. David Hopper. Ottawa, 1975, 42p.

IDRC-049e

The international exchange and testing of cassava germ plasm: proceedings of an interdisciplinary workshop held at CIAT, Palmira, Colombia, 4–6 February 1975. Barry Nestel and Reginald MacIntyre, editors. Ottawa, 1975, 74p.

IDRC-050e

The science and technology policy instruments (STPI) project. IDRC. Ottawa, 1975, 12p.

IDRC-051e

Integrated approach to local rural development: report of an interdisciplinary seminar, Makati, Philippines, 31 March–3 April 1975. Marilyn Campbell, editor. Ottawa, 1975, 52p.

IDRC-052e

Tropical oyster culture: a selected bibliography. D. B. Quayle. Ottawa, 1975, 40p.

IDRC-053e

Rice: postharvest technology. E. V. Araullo, D. de Padua, and Michael Graham, editors. Ottawa, 1976, 396p.

IDRC-055e

Cowpeas: home preparation and use in West Africa. Florence E. Dovlo, Caroline E. Williams, and Laraba Zoaka. Ottawa, 1976, 96p.

IDRC-058e

Removing constraints to small farm production: the Caqueza project. H. G. Zandstra, K. G. Swanberg, and C. A. Zulberti. Ottawa, 1976, 32p.

IDRC-059e

Cassava: the development of an international research network. Barry Nestel and James Cock. Ottawa, 1976, 70p.

IDRC-062e

Hidden harvest: a systems approach to postharvest technology. David Spurgeon. Ottawa, 1976, 36p.

IDRC-062f

La récolte retrouvée: pour une gestion intégrée des récoltes, de la moisson à la consommation. David Spurgeon. Ottawa, 1977, 36p.

IDRC-063e

The international exchange and testing of cassava germ plasm in Africa: proceedings of an interdisciplinary workshop held at IITA, Ibadan, Nigeria, 17–21 November 1975. Eugene Terry and Reginald MacIntyre, editors. Ottawa, 1976, 59p.

IDRC-071e

African cassava mosaic: report of an interdisciplinary workshop held at Muguga, Kenya, 19–22 February 1976. Barry L. Nestel, editor. Ottawa, 1976, 48p.

IDRC-076e

Intercropping in semi-arid areas: report of a symposium held at the Faculty of Agriculture, Forestry and Veterinary Science, University of Dar es Salaam, Morogoro, Tanzania, 10–12 May 1976. J. H. Monyo, A. D. R. Ker, and Marilyn Campbell, editors. Ottawa, 1976, 72p.

IDRC-TS1

Food legume processing and utilization (with special emphasis on developing countries). Alvin Siegel and Brian Fawcett. Ottawa, 1976, 88p.

IDRC-TS2

Maiduguri mill project: grain milling and utilization in West Africa. IDRC. Ottawa, 1976, 16p.

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